

SOME ENVIRONMENTAL EFFECTS OF DRAINAGE IN FLORIDA^a

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INTRODUCTION

The dominating geographic feature of south Florida is the Lake Okeechobee-Everglades basin. From the Lake the Everglades extend southward to the southwest tip of the peninsula. Agricultural development in the northern Everglades started in the early years of this century and is still continuing. Today this area is the largest single block of land in the state devoted exclusively to intensive agriculture. It is certainly one of the best-known agricultural areas in the country. The environmental changes this agricultural development has wrought in the Everglades are becoming more frequently a topic of public discussion on a national level.

The northern Everglades mucklands will undoubtedly reach the point of full development within the next ten to fifteen years, some 70 years after the first farmer's entry on the land. The

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environmental changes in the area itself, and in the larger area of its affect, are well-documented. Moreover, these changes have taken place rather slowly over a comparatively long period of time.

This presentation examines another south Florida region, one in which the process of drainage followed by environmental changes is now developing. In this region the process started less than ten years ago. When compared with the northern Everglades mucklands, the environmental changes in this region are taking place at a much more rapid pace, largely because of the greater availability of public and private investment capital, and the development of more sophisticated engineering techniques applicable to agricultural drainage. It is the authors' intent to examine some of the environmental changes which have taken place as a result of drainage and to indicate the interaction between the several elements of the total environment. The possible effects of changes within the region on the environment elsewhere are noted. Certain conclusions are drawn in which the proper role of public government in guiding environmental changes is suggested.

DESCRIPTION OF THE REGION

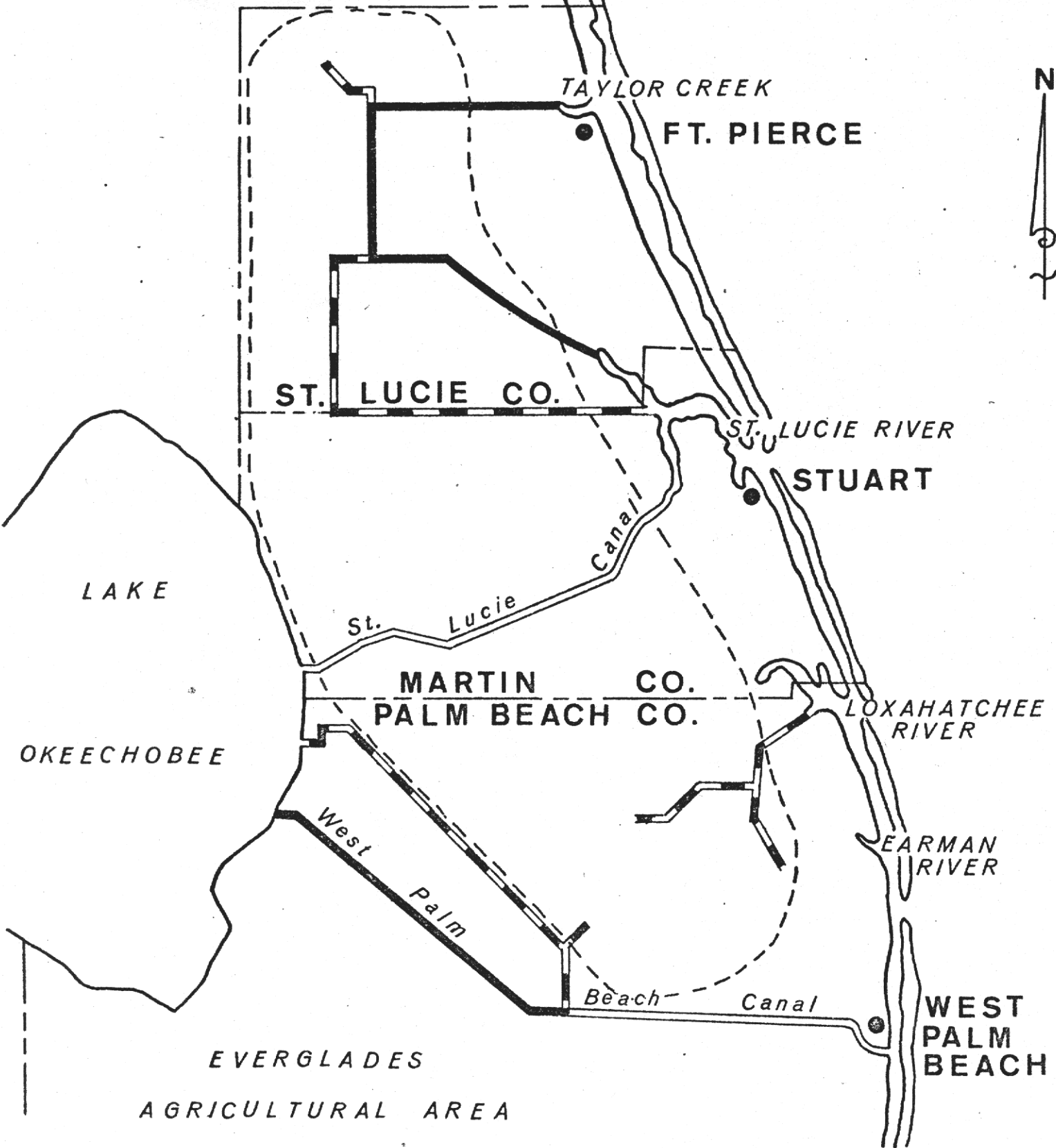
Paralleling the east coast of Florida a few miles inland is the Atlantic Coastal Ridge. Lying just east of Lake Okeechobee is another low ridge which extends northward the length of the State. The shallow flats and slough region lying between the Atlantic Coastal Ridge and the ridge east of the Lake, extending from the St. Johns headwater marsh on the north to the Everglades on the south, is south Florida's newest agricultural frontier.

This band of lower-lying land, up to fifteen miles in width, lies within Palm Beach, Martin and St. Lucie Counties and its location is shown on Figure 1. It includes areas locally known as the Loxahatchee, Hungryland and Big Cane Sloughs and the Allapattah Flats. Although the sloughs and flats are discontinuous, together with adjacent higher lands they nevertheless form a distinct topographic region some 780 square miles in area.

The region's appearance is characterized by numerous shallow, nearly circular, ponds, almost all of which are rimmed with cypress trees. At the south and north ends of the region the cypress trees grow in dense, wide bands around the ponds. These "cypress heads" are closely spaced and in high water times the intervening sawgrass strands take on the appearance of defined shallow streams. Figure 2 typifies the vegetative character of the northern portion of the region.


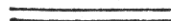
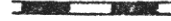
In the larger central portion of the area the characteristic ponds are present, without, however, as dense a cypress growth. In these flats are numbers of long, narrow sawgrass sloughs lying parallel to the boundary ridges. Imperceptibly higher ground extends in from the western ridge and fingers of higher land lie between the sloughs. In these "flatwoods" areas the vegetative cover consists of native grasses, scrub palmetto and scattered pine.

In its natural state this region affords excellent habitat for the majority of Florida's mammals, including the larger game species such as deer, bear and wild hog. In fact, a portion of the region in Palm Beach County is a State Game Management Area. Wild turkey can be found and many of the State's waterfowl species find excellent feeding grounds in the dense cypress head portions of the region.



LEGEND

Central & Southern Florida Flood Control Project Channels

-  Existing Prior To 1947 & Enlarged Under Project
-  Existing Prior To 1947 & No Project Enlargement
-  New Under Project

-  Approximate Boundary of Region
-  County Line

In these areas, the alligator can also be seen. In times of ample water, fishing in the area is good to excellent, particularly in the Loxahatchee Slough at the south end. In short, the natural environment of the region includes a good, if not abundant, fish and wildlife population of significant variety.

Topography is the single factor which, more than anything else, has determined the natural environment of this portion of south Florida. This 780 square mile region has no natural, defined, positive drainage outlet to either the Atlantic Ocean or Lake Okeechobee. Under normal and below normal rainfall conditions, water accumulates within the long narrow troughs of its sloughs and flats after the limited available ground storage is satisfied. Natural water level recession occurs solely as a result of evaporation and transpiration. Ground water levels remain high and many ponds, except in extreme droughts, hold some water all year round. Only with well above normal rainfall does outward drainage occur naturally; to the east through depressions in the Coastal Ridge at Taylor Creek, St. Lucie River, Loxahatchee River and Earman River, or, if water levels are favorable, north to the St. Johns Marsh and south to the Everglades.

The vegetative environment of pond grasses, saw grass and cypress, is typical of such a poorly drained area, as is the presence of the largely water-oriented animal and bird life. Although subjected to the natural vicissitudes of recurring dry cycles, the natural environment of the area is largely of the wetland type.

HISTORY OF DRAINAGE

Very little was done by man during the first half of this century to alter the natural environment of the region; that is, to alter its drainage characteristics. Early drainage improvements constructed within or adjacent to the area were undertaken in connection with development of the Everglades agricultural mucklands south of Lake Okeechobee, rather than to drain this region. As a part of the Everglades drainage program, in the 1920's the West Palm Beach Canal was excavated along the south edge of the region and the St. Lucie Canal was built from west to east across its central portion. The primary purpose of the former was to provide a drainage outlet for the mucklands developments, and the latter was excavated for the purpose of controlling water levels in Lake Okeechobee. The effect of the West Palm Beach Canal on the flats and slough region was negligible and that of the St. Lucie Canal quite limited, primarily because the region was felt to be of little value for agricultural purposes.

In St. Lucie County in the 1920's two aggressive drainage districts, whose lands were devoted to citriculture, indirectly accomplished somewhat more in the way of drainage of the northern portion of the region. Here again, the work was done not to drain the wetlands but to protect drainage district lands lying along the Coastal Ridge from excessive water accumulations in the flats to the west. The eastward draining canals partially served their main purpose. However, their greater effect was felt under normal, rather than wet, conditions since in these circumstances they provided some degree of drainage relief for the area to the west. As

a result a start was made on low-order pasture development along the east edge of the region in St. Lucie County. The basic character of the natural environment, however, did not materially change.

After the hurricane and flood of 1947, the Congress authorized the Corps of Engineers to prepare a comprehensive flood and water control plan for central and southern Florida. Although the entire 780 square mile region is within the Central and Southern Florida Flood Control Project area it is significant that the plan proposed very little drainage improvement for that portion of it in Palm Beach and Martin Counties.

Of equal significance is the fact that local interests voiced no objection to this lack in the comprehensive plan. Obviously, as late as the date of complete Project authorization in 1954, there was no clear thought that this portion of the region could be developed profitably for agricultural purposes, even with the assistance of a major Federal program, other than on a marginal basis.

In St. Lucie County the comprehensive water control plan contemplated a more ambitious program of flood control and drainage for the flats and slough region. Even here, however, when the first detailed plan for St. Lucie County was completed in 1957, a 30 square mile tract of cypress slough in the northwestern corner of the county was designated as a water storage area. The thinking of the Corps of Engineers' planners, and those of the Flood Control District, was at that time still based on the premise that most of the land in question was suitable only for water storage and, at best, improved pasture.

At this point a combination of circumstances and their convergence in time in 1959 and in space in northwestern St. Lucie

County initiated changes in existing patterns of thought concerning the lands in this region. These conceptual changes resulted in the opening up of new agricultural opportunities not hitherto thought available. Significant changes were thereby introduced in the natural, social and economic environment of the region and its area of affect.

It is probably never possible to clearly identify all the elements which enter into the making of a decision. The decision made by private enterprise in 1957 to convert the cypress heads of northwestern St. Lucie County into orange groves undoubtedly resulted from consideration of a number of factors. It is certain that among these were: a recent freeze affecting the citrus crop in the Ridge section of the state, the availability of large amounts of investment capital, a favorable determination of suitable soil characteristics, availability of land at a satisfactory price, and the imminence of Federal-State construction of major flood control, water control and drainage facilities. It would be pointless to attempt to select, from among these, the single most important determining factor in that decision. But it certainly can be held that these lands, no matter how suitable or how satisfactorily priced, were not usable for any intensive agricultural venture without drainage. As with the northern Everglades mucklands, in this area drainage was a major key to profitable agricultural development and, by definition, therefore, to the environmental changes which resulted from that development.

Under the influence of these factors a large tract of land in northwestern St. Lucie County was purchased in 1959 for citrus

planting. Approximately 9 square miles of the total 11 square mile purchase was within the area which had been delineated two years before as a potential reservoir site, but which could not be purchased by the State because of lack of funds for that purpose. Within a year the heavy cypress growth had been cleared, protective dikes built, pumps installed, the land graded, beds laid out, and trees set out on much of the tract. Although the major drainage outlet improvements had not yet been started, drainage for the tract was obtained by dike construction and pump installation. During this interim period excess waters were discharged over the dikes into the limited existing outlets to the sea or onto the adjacent undeveloped cypress sloughs. This particular grove development project was a going operation by the time the major Federal-State water control facility affecting the tract was completed in 1963.

This grove project, which can perhaps be best characterized as a well-calculated risk, was the ice-breaker. It stimulated a rapid expansion of similar development in the surrounding area. The movement of citriculture into the wetlands and flats of western St. Lucie County now took place concurrently with the construction of the Federal-State improvements during the period 1961-1964. The concurrence of these activities makes obvious the conclusion that availability of positive drainage was a factor in the conversion of the flats and slough region of St. Lucie County into highly productive agricultural use.

This activity to the north prompted another look at similar lands in Martin County, hitherto largely devoted to minimal seasonal

use in the form of native pasturage. Here a positive drainage outlet, the St. Lucie Canal, was already available; it simply had not been used to its maximum extent as a drainage outlet for adjacent lands. The potential for drainage relief being there, citrus expansion started in the Allapattah Flats north of the canal in 1963 and is still continuing. Grove development in the flatwoods area of the region is shown on Figure 3.

In the southeastern portion of Martin County, in the pond and slough areas west of the Coastal Ridge, a possible drainage outlet to the east was available by way of the North Fork of the Loxahatchee River. In 1965 channels to the North Fork were cut by private interests, thereby making possible the development of large contiguous tracts of grove land. A large part of this area is now in the process of being planted in citrus.

In Palm Beach County the first tentative step toward expanding citriculture in the slough region was taken in 1964. This was a comparatively small tract at the extreme westerly end of a small Flood Control Project canal discharging to the South Fork of the Loxahatchee River. Even though the tract is in the heart of the Loxahatchee Slough, the site was selected because of the availability of a positive, though limited, drainage outlet. To the south and west, in the Hungryland Slough, several large citrus grove developments were undertaken in 1966. The extent of this development is indicated by Figure 4. Here again, site selection was predicated to some degree on the availability of limited drainage outlets by way of either the West Palm Beach Canal or the Flood Control Project levee borrow canal on the west.

EFFECT ON THE NATURAL ENVIRONMENT

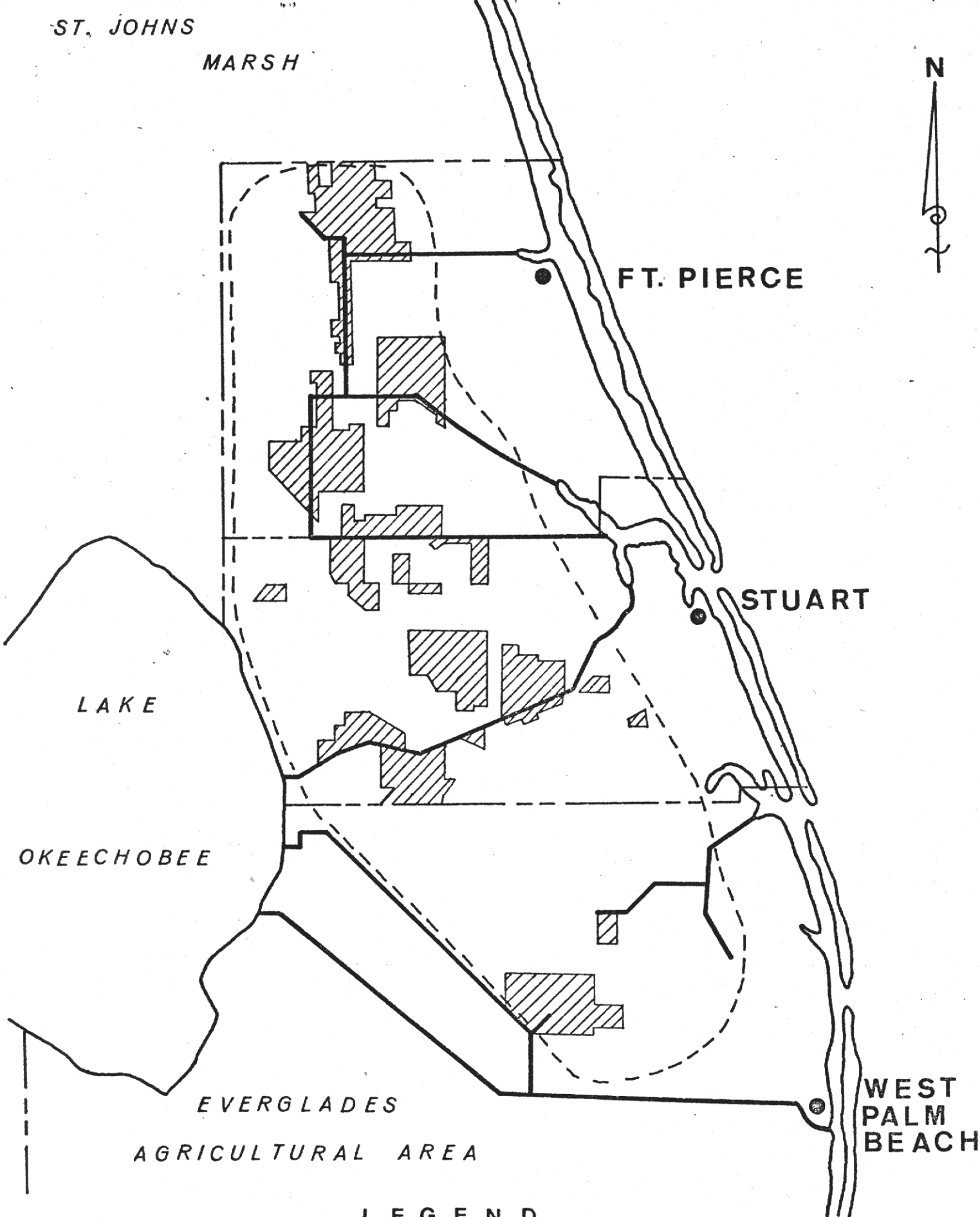
By 1967, over 150 square miles, or nearly 20% of the region, as shown in Figure 5, had been transformed from a natural wetland to intensively developed agricultural properties. This process, basically one of effective surface water drainage and groundwater table control, had the effect of eliminating a reasonably productive wildlife habitat in the tracts which had been drained. For example, the cypress sloughs and ponds of northwestern St. Lucie County were almost always wet year-round. Less than ten years ago, in the appropriate season, this marsh provided habitat for many varieties of migratory wildfowl. Drainage for agricultural development has now eliminated a large portion of this wildfowl area.

The change which drainage produces in the immediate natural environment is obvious. The diking, ditching and draining of a tract of wetland quite obviously eliminates that tract as a migratory wildfowl nesting or feeding area. The effect of such elimination, however, particularly if undertaken on a large scale, may well be felt on the natural environment of areas distantly removed from the region in question. It would be wholly speculative to say that drainage of the wetlands under consideration here has affected more remote areas. Nevertheless, such a possibility cannot be ignored when considering the effects of drainage on the natural environment.

Natural environmental changes, however, may well be in the making in certain areas outside of, but adjacent to, the specific region being examined here. Throughout this region the instrumentalities of effective drainage are artificial channels cut

ST. JOHNS

MARSH



FT. PIERCE

STUART

LAKE

OKEECHOBEE

EVERGLADES

AGRICULTURAL AREA

WEST
PALM
BEACH

LEGEND

- Approximate Boundary of Region
- County Line
-  Citrus Plantings As of 1967

through the Atlantic Coastal Ridge and discharging into natural tidal estuaries; Taylor Creek, St. Lucie River, and Loxahatchee River. Flows into the estuaries have increased in volume and in peak rates as a result of interior wetlands drainage. Seasonal distribution of flows has not changed, but seasonal volumes have.

Except for the St. Lucie estuary, no investigation has been made of the effect of increased fresh water discharges on the ecology of these estuaries. A study made of the St. Lucie estuary in relation to regulatory discharges from Lake Okeechobee by way of St. Lucie Canal did indicate that protracted fresh water discharges at high rates had a damaging effect on the estuarine biota. However, the study showed that once discharges ceased recovery occurred if the "no-discharge" period extended over a period of several months. The findings of this study cannot necessarily be applied to other channels draining the interior region, since both volumes and discharge rates are considerably less than Lake discharge volume and rates in St. Lucie Canal. However, it is perhaps reasonable to presume that some changes take place, even if only temporarily, and that these may possibly have a long term effect on the natural estuarine environment.

There also appears to be little question that some changes are being made in the quality of the water in the man-made canals draining to the coast. With a more intensive agriculture in the interior region the pesticide and nutrient loading of the canal waters and bottom sediments is undoubtedly increasing. The Flood Control District's pesticide monitoring program is a step toward defining the problem, if such in fact exists. Biological sampling

and analysis will gauge the effect of observed pesticide concentrations on the natural environment. Continued monitoring may indicate the desirability of extending the monitoring program to estuarine waters.

In terms of water quality, at the present time siltation is the item of greatest concern with respect to the natural estuarine environment. In those channels constructed and operated under the Central and Southern Florida Flood Control Project by public agencies, the Corps of Engineers and the Flood Control District, gated spillway structures have been provided upstream of the channel junction with the estuary. These spillways are operated as velocity control structures, designed to keep discharge velocities from exceeding the estimated erosive velocity. However, finer materials are carried in suspension in these canals and pass downstream where they settle out on contact with brackish waters. On a long-term basis this deposition of fine materials may tend to produce a limited and gradual change in the estuarine environment. Here, again, a program will be initiated by the Flood Control District to determine the sediment loads being carried by the major channels discharging into the estuaries.

No clear picture has yet developed concerning permanent changes in the estuarine environment resulting from fresh water discharges, siltation, pesticides and nutrients. Plans are now being developed for back-pumping portions of the annual runoff from this region into inland reservoir areas, including Lake Okeechobee, to augment storage. The back-pumping will assist in maintaining more closely

the natural ecological balance in the estuaries. This will be particularly so in the case of the St. Lucie estuary where high discharge rates resulting from Lake Okeechobee regulation requirements produce considerable sedimentation.

EFFECT ON THE SOCIAL AND ECONOMIC ENVIRONMENT

In considering the effect of drainage of this interior region on the total environment it can be said that perhaps the more obvious impact to date has been on the social environment. In this context social environment means the relationship between individuals, groups of individuals, and the public agencies representing them.

A sizeable segment of the community living along the Coastal Ridge derives its livelihood from providing services for a large seasonal population of tourists and a substantial population of retired individuals. In turn, many of these service enterprises are oriented toward the excellent estuarine and ocean fisheries in this reach of coast. These businesses, together with the large seasonal and resident populations they serve, constitute a substantial common, and special, interest group.

The concern of these interests over the possible damaging effect of increased fresh water drainage to the estuaries was immediately and vociferously expressed when agricultural development of the interior was undertaken in the late 1950's. This segment of the public became quickly allied with the various conservation groups. Initially rooted in economic considerations, the division of interests between the agricultural developers and

the coastal residents soon became a case of the proponents of "progress" versus those of "preservation". The extreme positions taken by both sides when drainage of the interior lands started in 1959 have now moderated somewhat. This has been due to some degree of accommodation between the protagonists, a recognition on the part of the responsible water resources development agencies of validity in the conservationist position, and quite frankly, an increase in the political weight of the conservationist groups. However, the underlying tension in the social environment still exists and a mutually wary attitude still obtains between the three groups; the agriculturists, the conservationists, and the water resource agencies. This tension has been evidenced again as private enterprise in southeastern Martin County has sought to secure grove land drainage by way of the Loxahatchee River and estuary.

The effect of drainage in this region on the economic environment can to some extent be evaluated by considering local tax income. As mentioned earlier, citrus acreage in this region now stands at over 150 square miles, with a production in 1967 of 3.9 million boxes from groves such as shown on Figure 6. In Martin and St. Lucie Counties, the areas of most extensive development, the local tax income from this region within those two counties now represents 9% and 15% of the total respective county tax income. In 1963 these figures were 3% and 8% respectively.

This method of evaluating economic impact is, of course, selective. However, the effect on the immediate economic environment, on local governmental income, is a valid effect to be examined. It is

apparent from the above figures that the immediate community has benefitted from interior drainage and consequent increased agricultural productivity. The development made possible, and sustained, by drainage has quite evidently been supporting an increasing share of the cost of the general community services provided by local government.

Although the total environmental impact may be separated into reasonably discrete packages, as has been done herein, there is in actuality a high degree of inter-action between the separable elements. This is particularly evident in the northern portion of the region considered here. The economic impact of drainage here was almost immediately favorable as a result of the change in the natural environment from undeveloped to intensively developed land. But citrus requires an irrigation water supply as well as facilities for excess water removal. The elimination by drainage of a natural storage area also eliminated its use as a managed water storage reservoir for agricultural water supply. Consequently, to maintain the new economy another source of water must be found. Lake Okeechobee is the logical source; however, competing uses for that supply bring to bear other social and economic forces outside the region. As planning now develops to augment Lake Okeechobee water supplies, for this and other regions, changes in the social environment are beginning to take place within the agricultural community itself, while the ever-present tension between agriculturist and conservationist once more increases. As a

consequence, great care must be exercised by the water resource agencies to insure that no single region's economic environment, as well as its natural environment, is unfavorably affected by actions taken to improve that environment elsewhere. The chain is one of inter-acting changes in the natural, social and economic environment which act further to produce similar changes elsewhere, and which, eventually, may feed back into the area of first concern.

SUMMARY

In much of central and south Florida, effective surface water drainage by man-made means is the keystone of intensive agricultural development. The region examined in this paper is typical of those areas in which this is the case. Drainage of such lands unquestionably results in direct and irreversible changes in the immediate natural environment. Typically, because of topographic peculiarities, drainage of Florida wetlands can affect the natural environment in adjacent areas. Wetland drainage in most areas of the country places agricultural, or other interests, at odds with conservationist groups; and this is the case with Florida. The changes in the social environment brought about by this division of interest must be recognized and dealt with. Finally, such wetland drainage inevitably produces some effect on the economic environment of the community. The region examined herein, quite typically for this type of development at this point in time, has had a favorable impact on its immediate community as expressed in terms of support of local governmental services.

However, changes in the area of immediate concern can produce wider-spread socio-economic environmental changes which, in turn, tend to feed back into the original system.

CONCLUSION

The impetus for much of the agricultural development described in this paper was supplied by private enterprise acting on its own initiative. Initially, the only constraints on this development were those imposed by fiscal and economic considerations; private enterprise's costs of development, including drainage, in comparison with projected economic returns. Privately-owned lands were drained and developed, and on those privately-owned lands the natural environment was irrevocably changed. This has historically been the prerogative of the landowner, a right which goes with the ownership of the land.

As agricultural improvements progressed in the region, an awareness of the possible impact of this work on the coastal waters to the east developed, first among the residents of that area and shortly thereafter among conservation interests. It was no longer a clear-cut question of the rights of the private landowner to make use of his property as he saw fit, but it became a question of possible impingement on the rather vaguely defined rights of the general public to enjoy "unpolluted" estuarine waters. By raising this question in this manner, coastal residents and conservation interests sought to preserve the economic, social and esthetic environmental values they had historically enjoyed; attempting thereby to impose an outside constraint on the development of the interior region.

This conflict of interests, involving questions of private rights versus public rights and questions of one class of private or public rights versus another class of private or public rights, developed within and around the framework of a government-financed plan for water resource development and use. This plan which, when prepared, had not contemplated such conflict, nevertheless acted as a catalyst and eventually became a focal point of public discussions. Public government, and specifically the Flood Control District and Corps of Engineers, necessarily became intimately involved in major public policy questions arising from developments in this region. From this experience some conclusions can be drawn concerning governmental responsibility.

In dealing with matters affecting our environment the question of the proper role of public government, in its broadest sense, is perhaps the most vexing to answer. To assess the role of government it may be necessary first to define the term "environment". To that segment of the public concerned with preservation and conservation of our natural resources of land, air and water, the term, almost exclusively, means the natural environment. To that portion of the public which can be characterized by the words "private enterprise", environment largely means the economic environment. Governmental bodies and agencies have, in the past, tended to align themselves with one or the other of these apparently mutually exclusive definitions.

In this presentation the authors have considered the term "environment" to consist of both the natural and economic environments, as well as the social environment. None of these elements

is mutually exclusive and, in fact, they are interacting and thus inseparable. If this is a valid definition for the term "environment" then perhaps the proper role of public government can be more clearly seen. It is suggested that this role first be one of properly weighting, to the best of its ability, the interests of all segments of the public in matters affecting the total environment. Subsequently, the proper function of government might well be the guiding of total environmental changes within the framework of its estimate of the "best public interest" through reasonable use of those means within its command: financial, persuasive, and regulatory.

Within the region discussed herein government, at several levels, has to some extent now gone through this weighting process. As a consequence, proposed additions to the Central and Southern Florida Flood Control Project in Martin County have been modified to reflect a more balanced view of the general public interest. Here government has applied the financial means at its command to guide environmental changes.

The 45,000 acre State Game Management Area, located within the region in Palm Beach County, is still being maintained intact. Through the efforts of the Flood Control District, the agricultural development to the south of the Management Area has been planned in such manner as to enhance water control for game management and for preservation of the natural environment to the north. In this instance the means government has at its command to engender cooperation in planning has been applied.

INFORMATION RETRIEVAL

KEY WORDS AND ABSTRACT

SOME ENVIRONMENTAL EFFECTS OF DRAINAGE IN FLORIDA

KEY WORDS: Agriculture; conservation; drainage; economics; environment; estuaries; flood control; irrigation; natural resources; sedimentation; water quality.

ABSTRACT: In 1959, intensive agricultural development started in a 780 square mile region lying east of Lake Okeechobee in south Florida. In this "wetland" region of flats, sloughs and ponds effective drainage to coastal waters has been the key to agricultural expansion. By 1967 approximately 20% of the region was planted in citrus. Changes in the natural environment within the region took place almost immediately after drainage was initiated and indications are that the natural environment in adjacent areas can be affected as well. The effect of drainage on the immediate economic environment of the region has been favorable to date. However, natural environmental changes have produced tensions, with economic overtones, in the social environment resulting in conflict between agricultural and conservationist interests. Based on the experience gained in this region it is suggested that the proper function of public government is to evaluate the possible environmental effects of drainage programs and to use its financial, persuasive and regulatory powers to guide total environmental change in accordance with its estimate of the best public interest.

Finally, government is beginning to exercise its regulatory powers, particularly in questions relating to the St. Lucie Canal and estuary, to ensure, at least, that no further degradation of the quality of the water entering that estuary occurs.

Much remains to be done, here as elsewhere. This presentation indicates the nature of some of the environmental changes which result from drainage of natural wetlands in south Florida. It also suggests that public government must assume a prominent role in guiding these changes.

CIVIL ENGINEERING ABSTRACT

Some Environmental Effects of Drainage in Florida, by W. V. Storch and R. L. Taylor. Documentation is presented of some environmental effects observed as a result of intensive agricultural development consequent to drainage in a region of southeast Florida. The role of government in guiding changes in the natural, economic and social environment is suggested.

FIGURE CAPTIONS

- Figure 1: Location of Region
- Figure 2: Undeveloped Land in St. Lucie County
- Figure 3: Grove Development in Flatwoods Area, Martin County
- Figure 4: Young Groves in Palm Beach County
- Figure 5: Areas Planted in Citrus as of 1967
- Figure 6: Producing Citrus Grove in St. Lucie County

